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Interactive Qualifying Projects (All Years) | Interactive Qualifying Projects

August 2012

Artificial Intelligence in a Game-Like Tutor

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Interactive Qualifying Project Report completed in partial fulfillment

of the Bachelor of Science degree at

Worcester Polytechnic Institute, Worcester, MA

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July 25, 2012

Table of Contents

1 Abstract

This report will discuss in depth the challenges and opportunities that arise when attempting to develop a tutor with game-like elements. In this report, the reader will learn background knowledge behind the importance of developing an innovative tutor for grade school students. The reader will also find the many trials and complications that arose during the design phase of the project. The idea behind this project should not be seen as complete. This paper should be used as a stepping stone for future work in this field. There is a growing need for the expansion of tutor systems like the one found in this paper as many of today's students struggle to learn using traditional study techniques.

2 Introduction

Modern schools have more to deal with than ever before. Some of these challenges include; high standards of public expectation on education, diversity in learning styles of students, technological challenges, and market pressures. These are all issues that schools and school leaders can by no means avoid. High expectations for all students reflect the realities of the modern society. Students come from increasingly diverse homes and backgrounds. This indicates that they are less likely to be driven by one simple, universal motive, which teachers could traditionally count on. While technology creates new learning opportunities for teachers, students, and parents, it also requires a certain level of understanding, especially from instructors, to use the right technology in education. Finally, the exploding education market is proposing new service delivery schemes, introducing more fierce competition, and expanding choices available to students, parents, teachers and administrators. However, even in the midst of this chaotic situation, motivation remains to be a subject of great interest to both educational leaders and researchers. How do we motivate students to study hard and meet expectations? In what way can modern technologies, such as the Internet, be used to make learning more appealing and thus gain more share of the education market? These questions still lack clear and convincing answers.

Our group also realized the potential of motivation to bring drastic changes to the current education system. Therefore, we decided to start a project with the goal of finding out more about this topic. After several discussions between our group members, we chose to focus on the use of common, appealing elements of video games in educational software as a means of motivation.

So what would make students want to study a subject outside of class time? This is where the idea of video games and the many different elements they utilize come into play. What are some techniques that game designers use to motivate players? Can these be used to motivate and teach students different subjects? For these questions we decided to find a solution in the form of a tutor that includes special features to entice and entertain students while still teaching them and honing their speed and comprehension.

The fact of the matter is our current educational system lacks the ability to motivate students. Between Attention Deficit Disorder (ADD) and generally shorter attention spans, students need something quick and entertaining to keep their interest. Using elements from video games to create something that will challenge pupils and keep their attention long enough for them to learn the material is an idea we considered to have great potential. So the focus of our project became the use of popular elements in games to create something both entertaining and educational.

Since our project was based on the implementation of game-like elements into a system that could teach and motivate students, we will start with a brief introduction on what game-like elements are. Game-like elements are elements that are utilized by traditional games. These include elements such as; reward systems, Artificial Intelligence (AI), hints, achievements and more. All of these elements present different motivators and each has the potential to be used to create an interesting and educational experience. Games used for entertainment purposes hold the attention of millions of players around the world. We assumed that the idea of integrating the elements used in video games into educational tutors as a way to attract students to learn we be similarly affective. The big questions thus became just what elements lend themselves best to the educational side of the equation? How does an individual properly adapt them to an educational environment?

The first step in the process was choosing an element from games that we felt would work the best. There are so many ways that games successfully appeal to multiple audiences and mind sets, that choosing one became a very difficult task. The challenge was finding something interesting that could lend itself to teaching. Artificial Intelligence was the element we kept coming back to when trying to make our decision.

Defined as "the study and design of intelligent agents" (Poole, Mackworth, & Goebel, 1998), where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success (Russell & Norvig, 2003), AI is so broad that it can be applied in numerous different areas. One common way of defining AI in Education is “any application of AI techniques or methodologies to educational systems”, which summarizes educational AI in general. Other definitions have a narrower focus. For example: any computer-based learning system which has some degree of autonomous decision-making with respect to some aspect of its interaction with its users (Self, 1995). This second definition stresses the requirement that AI techniques should be able to reason at a certain level while interacting with the user. The reasoning might be about the subject being taught, the best teaching approach, or about misconceptions and gaps in a student's knowledge. However, there are other ways of involving AI in teaching. For example, AI in education is sometimes defined as the use of AI methodologies and AI ways of thinking applied to discovering insights and methods for use in education, whether AI programs are involved at the point of delivery or not (Naughton, 1986). In practice, these contrasting approaches form a comprehensive description of AI in education. Although these works introduce both extremes of the definition, what all of them have in common is that the design principles of the systems are substantially derived from, and expressed in, the language of Artificial Intelligence (Self, 1995).

Accordingly, to make our tutor more entertaining and more effective, we decided to design an appropriate AI that could be used in an educational environment, possibly in the form a computer opponent similar to those common in commercial video games. The benefits of including an opponent in our project were that it not only allowed us to test competition and how students reacted to it, but also created a sense of interaction which is less prevalent in existing tutors and practice systems. With this system we would need to experiment and see whether presenting an opponent would motivate students to keep using our tutor.

Using the AI element allowed us to create competition in our tutor, a motivating factor throughout time. Using personal experiences, we assume that humans are competitive by nature. In games, competitive elements are usually the source of enjoyment and factors that foster the selection of computer-games as offers of social competition, in which the user competes against an opponent that is controlled by the computer (Vorderer, Hartmann, & Klimmt). On a basic level, competitive elements could be incorporated by our proposed tutor system due to their interactivity, which allows for active engagement of the user in the playing process, and for immediate feedback on the user's actions. On a broader level, the user's desire to play against an opponent likely evokes a competitive situation that should be especially capable of engaging the user. Therefore, it appeared reasonable to add competition as a factor in our tutor to help guarantee enjoyment and students' preference for using it.

In this particular case, we hoped that by adding a computer opponent supported by AI, our users would be provided with a simple yet consistent goal: beat the computer opponent. We assumed that students would enjoy competing against a computer opponent instead of simply answering questions on a computer-based quiz outside of class. Students would not just answer questions passively, but be stimulated while using the system because of their desire to prevail in the competition. This way, the ultimate goal of helping them to learn in a more efficient way would be achieved. Nonetheless, it still required more observation for us to answer the questions about whether or not competition is a positive or negative influence on education. There have been connections between education and competition in the past. Students tend to compare themselves with their peers and judge their performance based on others around them. Giving them an opponent that needs to be outsmarted might be a way to involve them in a healthy competition with an emphasis on education, but we still needed to check reactions from students after our project came to a more mature stage.

Finally, as for what the competition would be and how the students would interact with their opponent during the problem solving process, we didn't have a completely clear answer yet. But since we were focusing on math as a subject for our tutor, we had an initial idea of creating competition of speed and correctness, specifically about who (the player or the computer opponent) could solve the problems faster. The idea of a speed competition was to push the player to be prepared for many different problems proving their handle on the subject. They need to think of what they have learned in class within a short period of time and organize the knowledge in a meaningful way to finally come up with the solution. The AI opponent would offer a measure of how well they understand the material. However, the measure is not the same for all players, but instead is highly personalized to each user. The way we hypothesized it was, if they lose to their opponent, they will want to be faster so that they can win next time. Unlike most games, there wouldn't be some puzzle to solve or some shortcut to victory; to win they'd need to hone their knowledge of the subject. We hoped that they would be stimulated by failures in the tutor to study harder and be encouraged to learn more by the sense of success provided by the game.

3 Background

Recently, researchers have started to dive deeper into solving the issue of how to integrate the tried-and-true old-school teaching methods with modern technology. The idea of developing a system that implements game-like elements into the classroom could change education forever. But why games?

3.1 Challenge

First, a main driving factor in why using game-like elements could help modern education is that people general respond to challenge. Students in the classroom are no different. They too take action when presented with challenges. This is a fundamental concept for why this idea has a great potential to change the field of education. Games have the ability to present students with a vast variety of challenges and entertainment.

True learning and understanding of material occurs when the level of challenge or difficulty is appropriately met with the level of attainability[1]. What happens when a middle school child in class is presented with a problem that they view as too challenging? We strongly suspect that the child will declare the problem impossible, decide the teacher has given them an unsolvable problem, and figuratively "check-out" without truly attempting the problem. An excellent way to overcome this roadblock is through the use of game-like elements. When presented with an enormously challenging task in a game, it is viewed as much more attainable. In a game, if the student does not succeed in the first attempt, they have the ability to go back and try again. The bar may seem outside their grasp, but they usually feel that with some practice, they will be able to reach it.

Game-like elements are also a great idea due to the fact that they change the way a child views errors and mishaps. They are not viewed as failures, but instead they are viewed as opportunities to improve[2]. Quizzes are meant for teachers and students to gauge the understanding of a subject in school. But that is not all that comes from quizzes and exams. Students also have an emotional reaction to these tests. If a student receives an "A" on their math exam, it makes them feel good and gain confidence in the subject. But what happens when the student's friend receives a "D" or an "F" on the same exam? We suspect the student will be filled with worries that they have failed and will not be successful moving forward. What if we could keep the positive reinforcement of receiving that "A" and get rid of the negatives that result from being

[1] Differentiating Instruction: Rethinking Traditional Practices - Bertie Kingore, Ph.D. - http://www.bertiekingore.com/diffinstruct.htm
[2] Why Games Work - http://www.arcademicskillbuilders.com/why/

unsuccessful? The answer may lie within games. When a child is unsuccessful in a game, they do not immediately feel like a failure. On the contrary, they almost always view it as an opportunity to try again, improve their skills, and ultimately be successful. Educators should start to consider implementing a game-like feel into their various evaluation techniques to encourage their students to feel like they have a chance to improve, rather than allow them to always view their errors as failures.

3.2 The “Unlimited Ceiling” Effect

Another element that could be taken from modern gaming is the "unlimited ceiling". When taking an exam, students are limited with how much success they may attain. If a teacher gives their students a 10-question exam, students only have the ability to get 10 out of 10 questions right. Thus, there is a "ceiling" to the students' success. How could you maximize this "ceiling"? You could possibly make the exams longer and extend it to 100 or even 1,000 questions, but that is simply ineffective. It does not maximize the ceiling in an efficient manner. This is where games come in. Games have an unlimited ceiling when it comes to education. This idea of the unlimited-ceiling would help students gain maximum proficiency within a subject. If they felt unsure on the matter, they simply go back and play again. The student gets a new set of problems on the same material. This in turn allows the student to gain maximum exposure to the material. They can play and re-play the game until they feel they have sufficiently strengthened their own individual understanding of the subject.

3.3 Inspiration and Stimulation

An important factor that must be kept in mind is the ability to inspire and stimulate the students' minds. What does this mean for an educational game though? A student should not sit down and feel bored or obligated to continue when playing the game. There must be an aspect of the game that makes the user feel superior and inspires them to continue on. One way to do this is to have a system in the game that varies the difficulty of each question as they are presented. In simple terms, the game should provide some questions that are intended to be much easier to boost the student's confidence, as well as difficult questions that force the student outside their comfort zone and inspire them. Students respond to both of these aspects, challenge and success. A good way to ensure the student receives this effect is to have the game provide simpler problems at the beginning of each new round. By providing simpler problems at the start of each new round, the game strives to boost the user's confidence. This gets the user feeling good and puts them in a positive state of mind moving forward. The problems should then vary in difficulty; however, the difficulty should be generally trending towards more challenging problems. This allows us to force the students to see easier and harder questions which in theory should allow each student to experience the feeling of success as well as challenge. But what quantifies these questions as more or less difficult? Isn't each classroom in the world filled with students of varying proficiencies? Ideally, an educational game would keep track of each individual student's proficiency. This would then allow the game to provide tasks that involve varying levels of difficulty and incorporate level of challenge to account for each student's individual readiness level.

3.4 Attention Spans

Children in the United States have relatively short attention spans compared to the length of a classroom lesson. Based on personal experiences, we assume our target age group's classes to average about 1 hour. This is much longer than the average middle school student's attention span, which varies from about 8 to 14 minutes[3]. Attention spans of modern students, however, are generally elongated when using games. But if games are such an obvious answer, why don't more successful educational games exist? Research points out the obvious. Either the game is too educational and students lose interest too quickly, or the game lacks enough educational content to be seen as valuable in the eyes of the educational community. Other reasons many of these products fail are that they provide misinformation or simply bad lessons of arithmetic. Based on these factors, we believe a good way to be successful in the educational game market is to provide a tutor system that is not only educational, but also has well-designed and entertaining game-like elements. We believe these approaches may not have been extensively explored so far within the market of educational games.

Another way of keeping the students' interests and elongating their attention spans is to have the game cheat. What kind of cheating could help students stay interested in an educational game? One form of this would be rubber-banding. Basically, rubber banding ensures that the student does not gain an excessive lead on the CPU opponent. This technique is used in many of today's video-games such as "Mario Kart" or "Burnout". When the player gets out to a large enough lead, the game has an

[3] As reported by Louis Pugliese (Lecturer in Educational Psychology, CSUN, Certified by the National Board for Professional Teaching Standards)

internal algorithm that helps the computer-controlled opponent catch up to the player. This promotes competition. Applying this concept to an educational game could improve the game's interest and encourage more students to use the game more often and for greater lengths of time, leading to more exposure to the material at hand.

4 Design 0

Design 0 was our initial design. This would be our starting point and the basis for all subsequent designs. After completing it, Design 0 was presented to a boardroom of our peers and advisors.

4.1 Initial Idea

The idea of adding an AI opponent to a math tutor was inspired by a word-forming computer puzzle game named Bookworm Adventures, which combines the "create words from sets of letters" aspect with several elements of a typical computer role-playing game. It is certainly a source of entertainment, but includes an educational purpose of vocabulary expansion as well. These aspects are very similar to what we would like to embed in our proposed tutor.

In the game, players guide Lex the Bookworm through a number of stages, battling creatures along the way. The stages are arranged in order of difficulty so that the player can gradually adapt to the pace of the game while still feeling the joy and challenge. As for the gameplay, each battle consists of Lex squaring off against a given enemy. Both Lex and his adversary have a health meter (represented by a number of hearts), which, when depleted, signals defeat. However, unlike more traditional role-playing games where players might injure their opponents with weapons or magic, forming words damages enemies in Bookworm Adventures.

Figure 4-1 ***Adventure map***

(http://www.mini-freegames.com/screen/en_bookworm-adventures/th_screen2.jp)

Words are formed from a grid of available letters. The longer the word that is formed, the more damage is done to opponents. Similarly, words generated using letters that are less common do more damage than those using only common letters. Each turn, letters in the grid are updated and players can form a single word by selecting them, while enemies use one of their available attacks to injure Lex, heal themselves, or otherwise make the battle more difficult. Lex automatically recovers all of his health between battles.

Figure 4-2 ***Boss battle***

(http://www.frictionlessinsight.com/revpics3/BookwormAdventures2/BookwormAdventures2A_small.jpg)

After a certain number of battles in the same chapter are won, a more difficult "boss" enemy is encountered. This makes the game even more exciting and challenging. If players defeat the boss, they complete the stage and are rewarded with a treasure. Treasures provide special abilities to Lex, such as a reduction in damage inflicted to him, or more damage generated from words containing certain letters. In some cases, rather than receiving a new item, an existing item is upgraded. After the player has accumulated more than three items, Lex must then choose three of them to bring along on later chapters. Such a reward system not only gives players a sense of self fulfillment, but also serves as a highly personalized difficulty adjusting mechanism since players always choose those treasures that match their playing styles best.

Figure 4-3 ***Treasure system***

(<u>http://1.bp.blogspot.com/-Yl8trt5uhYA/TmFgbkDm7yI/AAAAAAAARD4/LYDMZTeyly8/s640/Bookworm+Adventures+Volume+2+3.jpg</u>)

So after a complete analysis of Bookworm Adventures, we found several features that could be deployed in our game design. First, we modified the computer opponent in the above game setting to make it more applicable in an educational environment. We considered using AI to dynamically adjust the intelligence of the enemy so that students of different math skill could experience similar levels of challenge. Second, we wanted to have “battles” in our tutor, but they needed to be simple and fast. The “battles” of

Bookworm Adventures are stimulating and visually appealing for a developmental game with a focus on entertainment, but they might not be appropriate for an educational tutor with a pure goal of education. What we wanted to do was to reduce the entertainment portion, which might distract students from the educational purpose of our game, and to make the fighting mode more straightforward to the extent that math questions became the only highlighted part. Last but not least, we also borrowed the idea of a reward system and “chapters” from Bookworm Adventures. These were not necessary, but they were expected to encourage players to spend more time in the tutor.

4.2 Design

In our initial tutor design, we defined the elements involved in a systematic way by referring to the integrated model for educational game design proposed by Brad Paras and Jim Bizzocchi (2005), which highlights motivation, flow, play and reflection. According to Paras and Bizzochi, an effective learning environment should not only include reflection in the process of play but also produce an endogenous learning experience that is motivating.

4.2.1 Motivation

For tutor designers, to motivate a user means to stimulate his or her interest in the system and thus engage them in the intended process of knowledge gaining or skill development. In fact, this is mostly the same as what games want to achieve, except that the ultimate goal of a tutor is to educate users instead of entertain them. To be more specific, there are two kinds of motivation that can be used in a tutor, extrinsic and intrinsic. In general, an activity is said to be intrinsically motivating if there is no obvious external reward associated with the activity. Conversely, an activity is said to be extrinsically motivating if engaging in the activity leads to some external rewards like food, money or social reinforcement (Malone, 1980). In our tutor design, we decided to use both motivation methods together to maximize the motivation effect.

In terms of intrinsic motivation, we came up with a storyline and a clouded adventure map to complement the development of the story.

Figure 4-4 ***Clouded adventure map***

Based on Sharon DeVary's work (DeVary, 2008), challenges and obstacles that are woven into a strong learning-related adventure develop higher-order thinking.

Therefore, we planned to let students experience a fun story while solving math problems, in the hope of using the story to encourage learning and thinking. The story didn't need to be realistic, but had to be related to math in some way so that we could naturally integrate problem solving into the tutoring system.

Moreover, in any given instructional situation, the learning task needs to be presented in a way that is engaging and meaningful to the student, and in a way that promotes positive expectations for the successful achievement of learning objectives (Small, 1997). In this case, we introduced the clouded adventure map component into our design. The map consists of several sites representing various chapters, which require different skills and knowledge. Users are supposed to enter the sites in a predetermined order. Each time they beat the opponent in one site, the cloud over a new site will be removed and the player will be allowed to explore it. We believe this can entice students to spend more time in the tutor and explore the "hidden world".

4.2.2 Flow

In theory, flow explains a phenomenon that many people find themselves experiencing when they reach a state of feeling a perfect balance between challenge and frustration, and where the end goal becomes so clear that hindrances fall out of view (Chan, 1999). To better balance the game experience, flow is something else that we took into consideration while designing the system. Past research has shown that the flow state has a positive impact on learning (Webster, 1993), and therefore should be taken into account in the design of educational software, which in this case refers to tutors. In practice, flow-like experience has something to do with the degree of complexity of the tutor. If the challenge is significantly greater than player's skill level, he or she may feel anxiety; in contrast, if the challenge is significantly lower than the player’s skill level, the player may feel bored (Kiili, 2005).

To address this issue, we implemented the difficulty selection system which allows the user to select a preferred difficulty level before starting the game. We also added dynamic difficulty adjusting, which makes the game more or less challenging based on the skill of the player, determined by a predefined algorithm multiple times during the game. Putting these together in our tutor, we would be able make the challenge that a player would face suitable, given the skill set of that particular player. Players also have a chance to adjust the difficulty setting each time a new chapter begins so that they don’t face the same level of challenge on materials of distinct familiarity levels. This also adds personalization to the user experience. In addition, once they begin to compete with the computer opponent, our system will continuously change the difficulty based on students’ actual performance and the difficulty level previously selected.

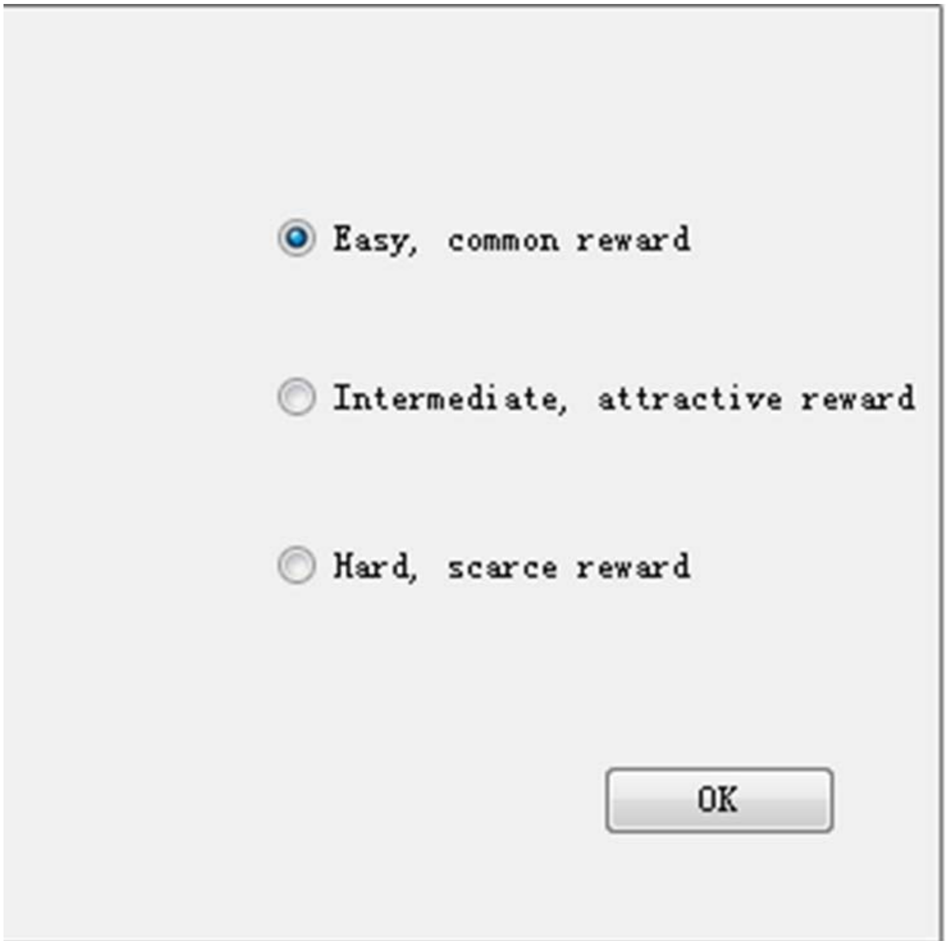


Figure 4-5 ***Difficulty selection system***

4.2.3 Play

As for the actual game play, our aim was to combine the arrangements mentioned above with a creative game play experience. To achieve this, we used the four key attributes of educational game Lepper and Malone (Lepper, 1987) came up with as a guideline for the coordination of the different systems. First, according to Lepper and Malone, games must introduce challenge. Through goal reaching and feedback, the learner should continually feel challenged as difficulty increases in concordance with increased skills. This corresponds to the dynamic difficulty setting mentioned before, which directly controls how the opponent performs in the game. Second, the game should create sensory and cognitive curiosity within the learner. We tried to achieve this goal by having a clouded map as well as developing the creative gaming mechanism of chasing by rolling dice. We believed that having part of the map covered with clouds could engage players' curiosity and the desire to explore. Making players try to chase and catch the computer opponent is also quite innovative compared to traditional tutors. These two characteristics were expected to increase users' interest in using the tutor and thus make the tutor more effective. Third, the learner should feel a sense of control throughout the game. This was accomplished by having the user-controlled difficulty selection system, which is common in modern games and is a good way to enhance game experience. Fourth, games should use fantasy to reinforce the instructional goals and stimulate the prior interests of the learner. To do this, we designed cartoon characters and included an imaginative storyline that links all the chapters together.

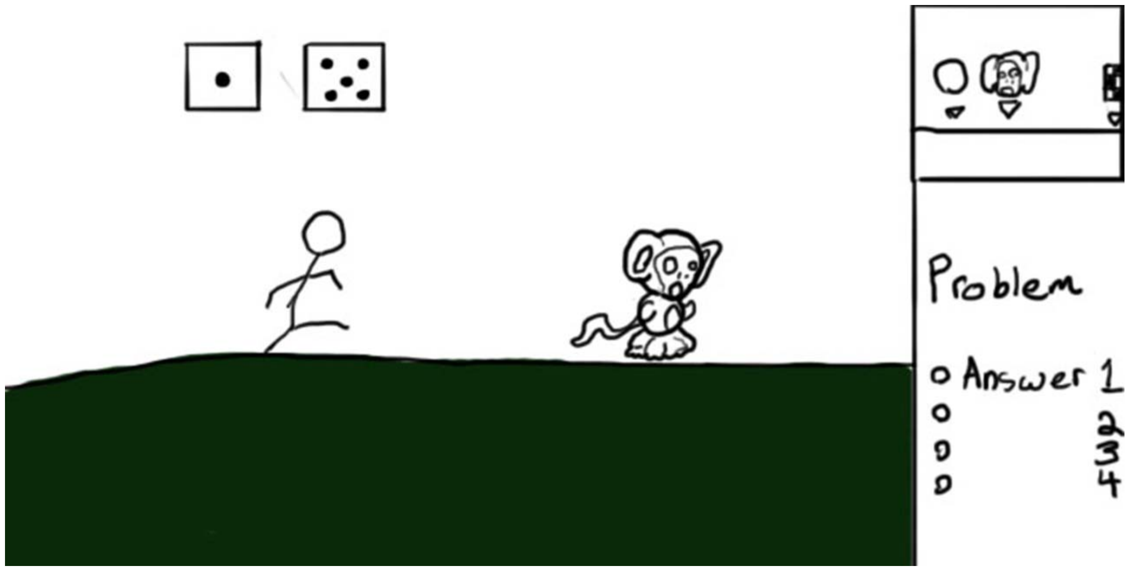


Figure 4-6 ***Game play***

4.3 Reflection

Last but not least, we were thinking of implementing an explanation system that gives the player a chance to reflect on points they don't understand well and consequently better gain the intended knowledge or skills. Nevertheless, the problem of an explanation system lay in that it seemed to have a break-up effect on the flow of the game.

After some careful research, we managed to find a solution with reference to Kristian Kiili's theory (Kiili, 2005), which is the endogenous implementation of reflection. Specifically, in educational game design it is important to ensure that learning takes place within the realm of play, even if learning is only made possible through reflection. To obtain such effects, reflection must appear to the learner as one of the many in-game goals that drive the game-play. As a result, we decided to link the explanation system closely with the game play by making a cartoon referee give the results and the explanation in a conversational manner. Later, we would test players on similar problems to confirm understanding.

5 Design 1

Design 1 was the first Design that included our initial design combined with ideas obtained feedback from presenting Design 0 to our peers and our advisor.

5.1 Main Focus

The main idea that we focused on upon updating our design was based on a game-play style called the "Predator vs. Prey"[4] style. The primal concept behind this is that the user is controlling either the "Predator" or the "Prey" and, depending on their roles, is trying to catch up to or escape from their opponent. This is a basic concept that has been used in games for many decades. Examples of such a concept can be dated back to the earliest games, such as "Pac-Man". Even though "Pac-Man" is such a basic game, it still keeps players interested 30 years later. We assumed that this can primarily be attributed to its general theme of Predator vs. Prey.

The primary goal or challenge within these games must not only seem challenging, but also must feel attainable. If the goal is too attainable and easy, then the player will likely become bored and stop playing the game. However, if the game is too challenging, then it becomes less interesting and dissatisfying. These are pivotal concepts to keep in mind when designing games based within the Predator vs. Prey game-style. Based on this knowledge, our team decided to commit to the Predator vs.

[4] Evolving Opponents for Interesting Interactive Computer Games - Georgios N. Yannakakis John Hallam

Prey game-play style. We believe that students will be more interested in an adventurous game involving a computer operated opponent with artificial intelligence instead of simply answering homework or quiz questions on a piece of paper.

5.2 Changes From Design 0

After presenting our initial Design 0 to our peers and advisor, we decided to make some alterations to different aspects of our design. These changes are based on the feedback we received from our presentation as well as research conducted subsequently.

5.2.1 Roles Reversed

Potentially the biggest change that was implemented when transitioning from Design 0 to Design 1 was the reversal of the roles within the game. As we stated in section 4.1, we decided to continue implementing the “Predator vs. Prey” game-play style; however, we decided to change the character’s roles in the game. In Design 0, the user would control a game character whose pet monkey was constantly escaping and running away. In this setup the user would be considered the “predator” while the opponent would be the “prey”. After having it brought to our attention, we realized the plot line would be very difficult to write and become repetitive quickly. This prompted us to change this dynamic.

In Design 1, we would have the user control a monkey as their primary character. Larger, more intimidating creatures such as gorillas or dragons would chase the monkey. This would provide a better base for writing a background story and plot line to the game. These opponents would constantly chase the user’s monkey and the user would have to use skills learned in the classroom, such as solving math problems, to advance their monkey and evade the creatures chasing the monkey. This in turn reversed the previous roles of “predator” and “prey”. In this updated version, the computer opponent would now be viewed as the “predator,” while the user would control the monkey which would be considered the “prey.”

5.2.2 Degenderization

Currently, interactive media and technologies, especially video games, are playing a more and more significant role in the lives of children. According to a national survey conducted by the National Institute on Media and the Family (NIMF), 92% of children and adolescents age 2-17 play video games (National Institute on Media and the Family, 2002). However, a substantial gender difference in computer games has been observed regarding both involvement and preferences, even with the use of digital games being on the rise. A report published by Kaiser Family Foundation claims that on any given day, 44% of boys report playing video games compared to 17% of girls. One possibility to explain this situation is the fact that the majority of commercial games are still being designed, developed, and marketed with the male player in mind, in spite of efforts to accommodate female gamers such as games by HerInteractive, Girl Games, Girltech and Purple Moon (Ibrahim, Wills, & Gilbert). Whatever the cause, girls generally show much less interest in video games than boys do.

An important factor attributed to the gender gap is violence. Whenever you look through a top sale list for video games, you can always find that most, if not all, of popular games targeted at teens and adults present an abundance of violent actions that display a high degree of realism. Game producers might tend to think that most girls are not gamers by nature, which also means they’re not as marketable as boys. As a result, they begin to put more and more element designed for boys in their games, making girls less and less likely to play them. Such vicious cycle makes the gender gap even larger. In reality, this kind of observation corresponds to research on media genre preference, which has demonstrated that males are more interested in violent entertainment than females are (e.g., Slater, 2003). On the other hand, females tend to display a very low preference for observing or participating in conflicts and their resolutions through violence (Bussey & Bandura, 1999) and find non-violent entertainment, such as comedy or sad films, more attractive (Oliver, Weaver, & Sargent, 2000). As is said previously, many computer games do not take females' preference for non-violent content into consideration. As a result, the lack of suitable non-violent games in the market might shed light on the reason why women and girls generally engage less in games.

Other than violence, boys and girls are found to treat competition distinctively. In his article, Lewis (1998) concludes that boys prefer direct or overt competition while girls prefer a more secretive or covert approach. Boys always feel the desire to “beat” the opponent and win the game, while girls often just take their time going through the game and experiencing the story, which seems more about establishing emotional attachment with the characters and events in the virtual world. This means it will be a rather difficult task for us to fine-tune the level of competition to make boys excited and girls comfortable. There are also similar findings informing us on how each gender manages conflict both in and out of a game: while the male generally resolves “a problem by direct confrontation with a decisive win-or-lose result”, females usually “choose negotiation, diplomacy and compromise” (Ray, 2004).

With regard to specific game theme or topic choice, Kafai (1998) discovered that boys tend to design games themes that allow them to “get something” through a pursuit or adventure exploration. By contrast, girls create games that involve “doing something” without finding objects. The game is the activity itself.

As to the characters appearing in games, two-thirds of the characters were male (64%) and the other one-third were either nonhuman (19%) or female (17%). Males dominated as player-controlled characters (73%), and even nonhumans (15%) outnumbered female characters (12%) for players to control. In a game designed for both genders such as our tutor, this could indicate problems: female users might have low attraction and find it hard to imagine themselves in the virtual word with the lack of female characters, and their enjoyment and playing motivation could be reduced in consequence. Therefore, we’re thinking of giving users the choice of character.

Concerning visual stimuli, the generally considered panacea in games, also have different effects on both genders. It is observed that even though both genders do respond to visual stimuli, their reaction is different. Males tend to show a physiological reaction but females need an emotional or tactile stimulus to elicit the same response (Ray 2004). In addition to that, girls prefer a “rich texture phenomenon” which includes audio and expressive graphics as well (Miller et al. 1996).

Finally, in terms of game play mechanism; achieving or beating a score is certainly the most common one to proceed through a game. However, do girls really like such kind of mechanism? To answer this question, Miller and Groppe (1996) discovered that girls view winning as not as important as the “experience” of playing the game. Turkle (1986) wrote about similar result in his paper, saying that males are more likely to take risks and experiment while females tend to seek understanding before trying. Since many games simply employ “trial and error” mechanics, it is not surprising that we end up with a relatively low amount of female gamer. So obviously, in order to attract girls, a game should use more gender-neutral mechanisms.

5.2.2.1 Implementation

During the actual design stage, we planned to degenderize our tutor on the five aspects mentioned in Kafai's (1998) article to mix and compromise factors catering to respective gender. The five aspects are game genre, game world, game characters, game feedback and game narrative.

5.2.2.2 Genre

First, we reinforce the decision of choosing adventure as the game genre. According to Kaiser Family Foundation (Kaiser family Foundation, 1999), among 8-18 year olds, the three genres that dominate kids’ video game playing are action or combat (42%), sports (41%), and adventure (36%). Boys who play computer games are more than three times as likely to play action or combat games compared to girls (27% v. 8%). They are also more likely than girls to play sports or competition games (23% v. 9%). Hence, adventure becomes the optimal solution to mitigating gender difference due to game genre.

5.2.2.3 World-style

Second, based on Kaifa’s experiment, boys prefer fantasy or virtual worlds, while girls prefer realistic settings such as the space of the home. In this facet, we considered using fantasy, but limited the settings to those of a typical fairy tale, which we believed would not make girls feel uncomfortable.

5.2.2.4 Player/Character

Third, Rachel Karniol et al. (2000) stated that children tend to anthropomorphize animal characters and develop affective reactions to them. This implies that an animal character, if properly designed, would be an ideal candidate for our tutor. Additionally, in a study with animal characters (Arthur & White, 1996), younger children were found to assign their own gender to bear characters. Yet even though older children do not assign gender to animal characters in line with their own gender, their preferences do reflect their own gender. Accordingly, we decided to cast a monkey in the game story and let the users decide its gender.

Figure 5-1 Character choices

5.2.2.5 Feedback

Fourth, we wanted to match our feedback system with girls’ general liking by making it nonviolent. Namely, we wanted it to be mild and cartoony (for example, see Figure 5-4). This kind of nonviolent modality does diminish the feeling of excitement within the game, but it’s expected to help maintain female users.

5.2.2.6 Narrative

Finally, a narrative was provided to support the storyline. Sarah Joy Bittick & Gregory K.W.K. Chung's (2011) research confirmed that the use of narrative in educational video games has the potential to increase student engagement and learning outcomes, especially for males. Thus, we made use of narrative to attract boys.

Figure 5-2 Map screen

After all the above steps had been completed, we had a gender inclusive tutor structure ready for more competitive elements.

5.2.3 "Cheating" Dice

In our original design, upon answering a question correctly, the player and/or opponent would be allowed to role an animated die that would produce numbers between 1 and 6 at random. After deliberation and receiving feedback on this feature, we decided to have the dice “cheat”. What does that actually mean though? Instead of the dice producing numbers at random as it was in our initial design, the dice would produce numbers to promote competition. If the player began to gain a substantial lead over the opponent, he/she would be more likely to roll a lower number. Inversely, the computer-controlled opponent would be more likely to produce a roll with a higher value.

On the other hand, the dice can also be used to elongate the game. Why would we want this? If the computer opponent begins to gain on the user too quickly then the game may end in the player being captured too quickly. We wanted to encourage the students to play regularly, so it was most likely in our interest to ensure that the character would not be caught too soon as this might discourage the student from continuing to play. It may make the game feel too challenging and not so attainable. Overall we feel that giving the game an internal system to control the competitive nature of the game using “fixed dice” will strongly benefit our game.

5.2.4 Removal of Difficulty Selection

As stated in Design 0, players would choose their own difficulty. This was our original idea to encourage the user to play at a difficulty they were comfortable with. This element had some previously unconsidered issues. Students would have the option of choosing to face challenging opponents or much easier opponents. However, the point of the game is to create a tutor that presents the student with goals that are both challenging and attainable. With this concept, we decided we would now implement a hidden scoring system to evaluate a player’s performance. The system would then use the score to influence how challenging the opponent would be. Students who were struggling would see less challenging questions and opponents that would not pressure them as aggressively. Students who were excelling would see many more challenging questions whilst his or her opponent applied added pressure. Using this system, all players would get a good distribution of challenge and attainability with respect to their proficiency level.

5.2.5 Feedback

First, we removed the concept of taunting from the game. In our previous design, upon answering a problem incorrect, the challenger would playfully taunt the user. The main reason we decided to remove this was the fact that it is simply too unpredictable at this point. We were very unsure how students would react to a computer opponent poking fun at their mistakes. We began to suspect that some students might become offended or discouraged. This was something we decided was just an unnecessary risk. To fix the problem, we would simply remove the presence of taunting from the game.

Along with the removal of taunting, we would remove the presence of the "Wise Goat" character (see Figure 5-3). His role in the game was to provide the user with an explanation as to why they got a question wrong if both the opponent and player provided incorrect answers. He was removed for similar reasons as taunting. Student's reactions to a computer lecturing them are just unpredictable at this point. We suspect that some students may feel put down being lectured by a goat in the game.

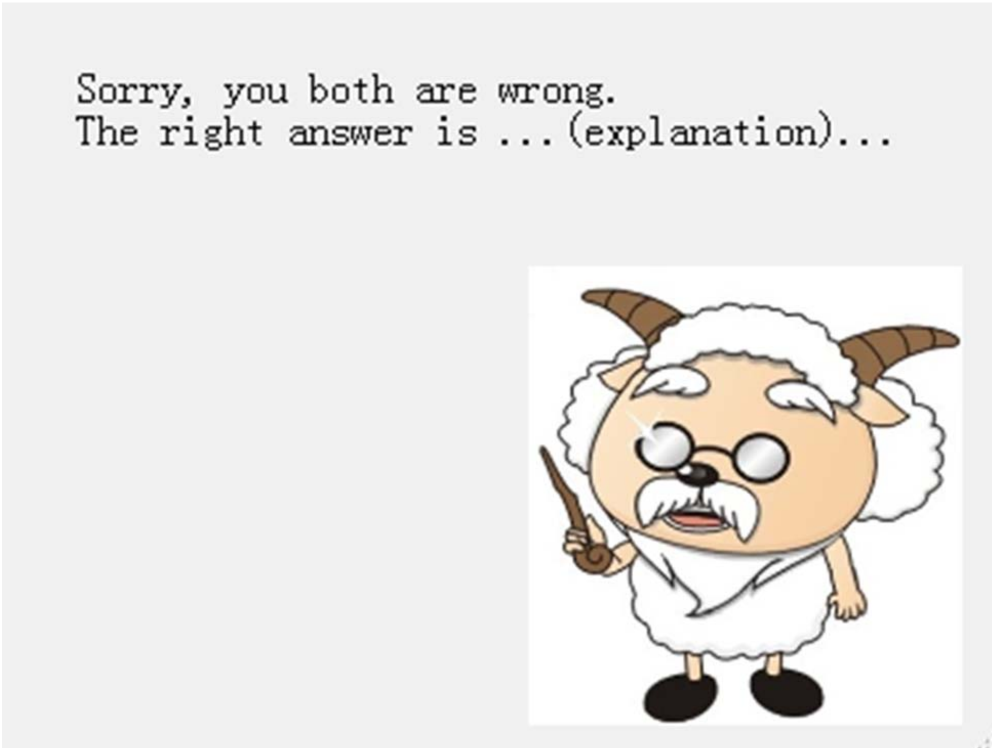


Figure 5-3 ***Explanation system***

Another aspect of feedback that was changed for Design 1 was the reward system. We found that with our game changing so much, the reward system would likely have to be altered as well. However, upon completion of the general concepts of Design 1, we did not have any concrete ideas for the reward system in the game. Design 1 was presented with no true reward system, but instead a plan to receive outside input concerning views on possible reward systems.

A new concept introduced with this design was the use of a hint system. If the player was taking a long time to answer a question, their monkey would have a sudden thought bubble containing a hint to assist the student (see Figure 5-4). This hint would try to give the student a basic starting place for the problem. We felt this would be a useful element within the game to assist struggling students with problems that were too challenging. This hint would pop up after a set time. This meant the game would need an internal clock to decide when to give the hint to the student.

Figure 5-4 Using a hint

5.3 Design

The actual gameplay of Design 1 would not vary too much from Design 0. Design 0 would be updated using the changes previously discussed; a new mock-up was created based on the role reversal of the opponent and the player (see Figure 5-5). The concept of a chase would still be the basic layout of the design. The other basic aspects, such as the mapping system, would remain unchanged from Design 0. A new mock-up for the mapping system (see Figure 5-6) was created, but the overall function and concept of it would remain unchanged.

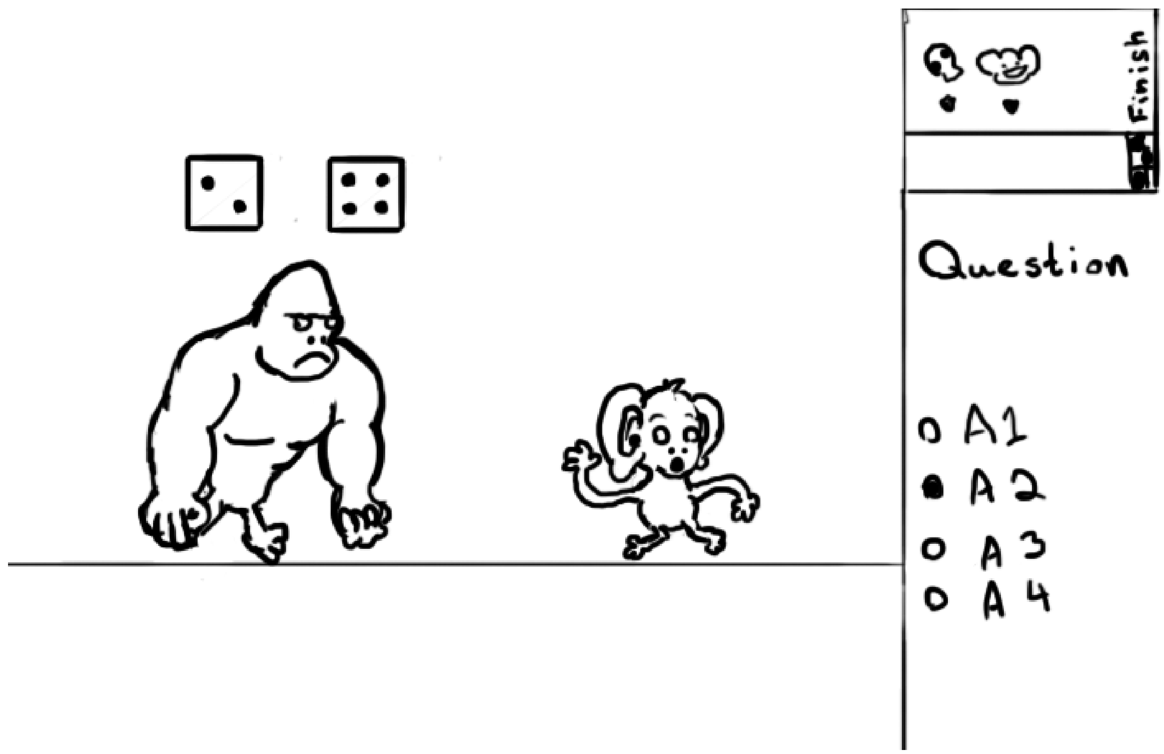


Figure 5-5 Design 1 mock-up

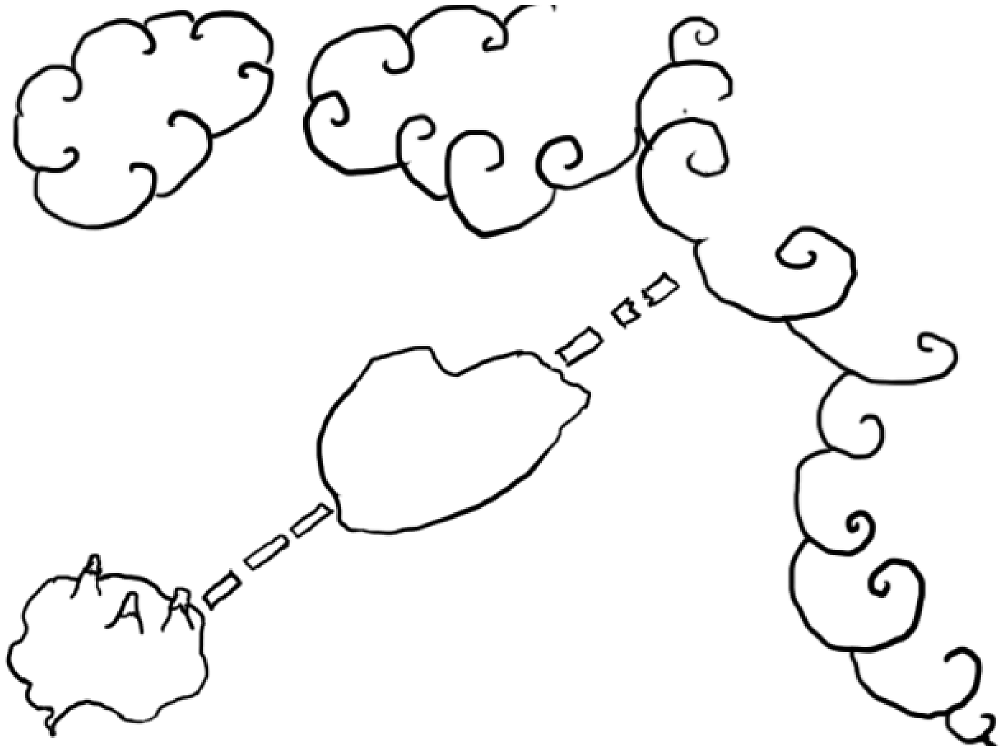


Figure 5-6 Design 1 map mock-up

6 Design 2

In Design 2, we focused our efforts on creating a working model for our target audience. We would be allowed to present this version to a group of students. This would give us useful feedback and help us hone our ideas.

On top of creating a working version, we had a great deal of useful feedback on Design 1 that guided us to focus more on the AI element of our project. In Design 1, one of our problems was the lack of focus we had on the element we chose to begin with. We stripped some of the features and decided to take a serious look at what we could do with AI. This brought out the algorithm and the idea of dynamic difficulty adjustment.

6.1 Changes

Originally our concept was a player-created character chasing his or her pet monkey. However, through feedback we were convinced to change to a predator versus prey approach, where the player is the monkey being chased by a larger creature of some kind. It seems very trivial, but it was a change that helped us create a much larger focus on the AI element of the game.

This new idea created many upsides from a design perspective. The player feels a much more urgent need to remove their monkey from the danger of being harmed by this much larger creature. This sense of urgency creates tension as the player is trying to escape their opponent. It also created a much more interesting story for us to create the game around. Players were no longer chasing a monkey, but were fleeing a large enemy, allowing us to use various pursuers and create new worlds for the monkey to traverse. There is also no longer the confusion of which character the player should really be helping; they gain a certain connection to the underdog. A simple swap of roles changed the game completely and laid the ground works for Design 1.

This change showed us just how many different elements we had implemented into our original designs. We would have to adjust them all or just drop them from the newest version. So we started thinking about what we needed and what was just getting in the way of our original goal. What we ended up realizing is AI had become one of multiple focuses in our project when it should have been the only one. In our previous designs there were multiple game-like elements that our group focused on, such as rewards and feedback. Although these were interesting mechanics for the player, it caused the core idea to fall to the wayside. The core idea behind our project was to use artificial intelligence to teach math skills in a game-like environment.

We decided as a group to remove the feedback and rewards from the game. The feedback was already the focus of a completely different group, so there was no need for us to try and create a system for it as well. If we wanted to return the feedback system later on we could first talk to the feedback group and possibly implement their ideas. The reward system, which we added as a way to motivate kids to keep playing the game, seemed like too large of an idea to spend all of our time on. Much like the feedback system, there were other groups working on reward systems that we could possibly borrow from in the future. With our project given a direction, we started developing ideas more directed towards AI and what we could do with it.

The competition between the player and the opponent had become a larger focus of our project. So we decided that it was all the motivation the kids would need to keep coming back, to try and be faster and beat the AI. The goals for the player and how we wanted to use our game-like element were all changed to reflect the new play style of the game. This small change gave us greater ideas of how to use AI in a much larger way then we were before.

Looking at possible ideas for how the AI would compete with the player, we developed the idea of using dynamic difficulty adjustment. This is a system in which the AI will get more successful as the player does the same and vice versa. We used the AI in the "Mario Kart" series as an example when first trying to develop this idea. In "Mario Kart", most players refer to the mechanic as ‘rubber banding,’ since the AI will fall behind but then quickly catch up using better power ups and a slightly boosted speed.

The purpose of this system was to keep the player from losing easily, as well as from beating the opponent too quickly. For example, if the player were to do well and get a sizeable distance away from the opponent, then the opponent would proceed to answer more and more questions faster and get better dice rolls than the player, allowing it to catch up. The game would essentially be cheating the dice, making the players come up with worse outcomes so the opponent could get closer. We wanted the opponent to always be uncomfortably close to the player, stressing that urgency and constantly creating tension between the player and opponent.

6.2 Play

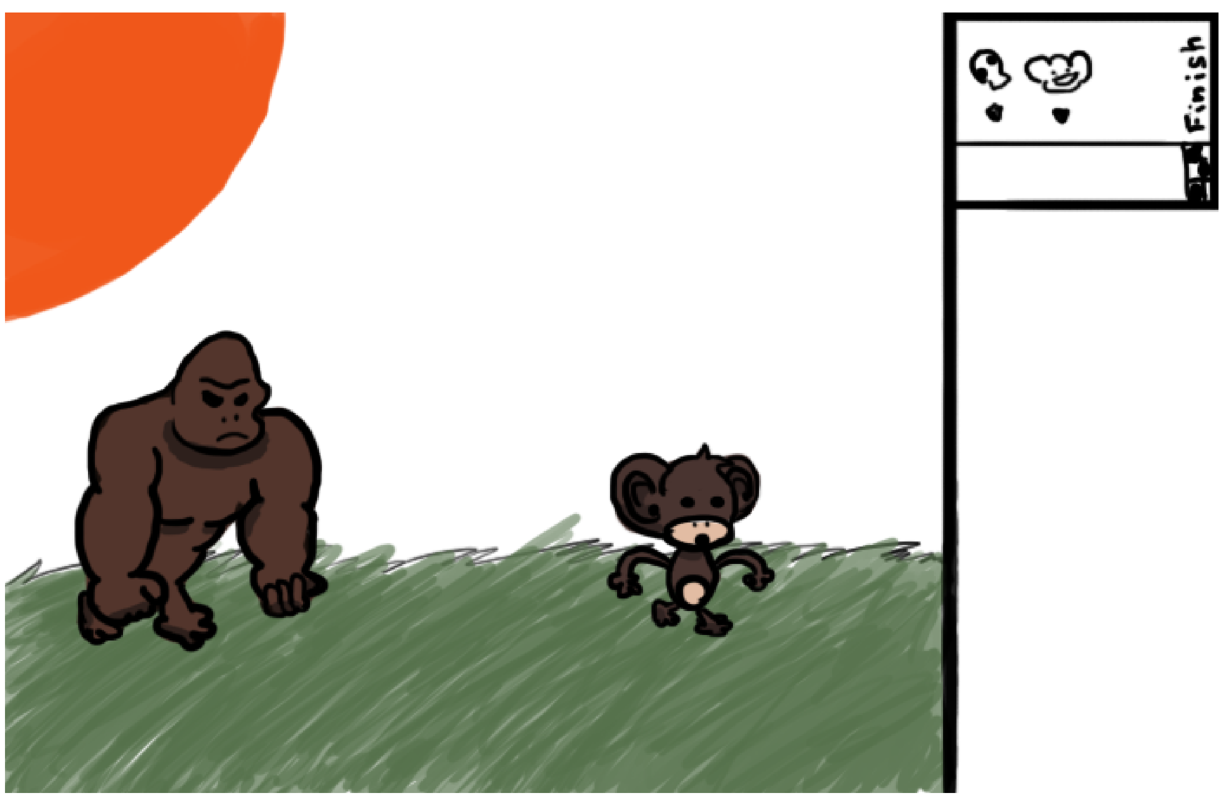


Figure 6-1 ***Gameplay Screen***

We didn't change how the player interacts with the system; they are still given multiple choices for the question, all displayed in the white rectangle on the right. This system is just how we believe the students will best use their skills without being overly distracted by the game side of it. We want them to focus on doing the problems to the best of their ability with an added flair of visuals to keep them motivated.

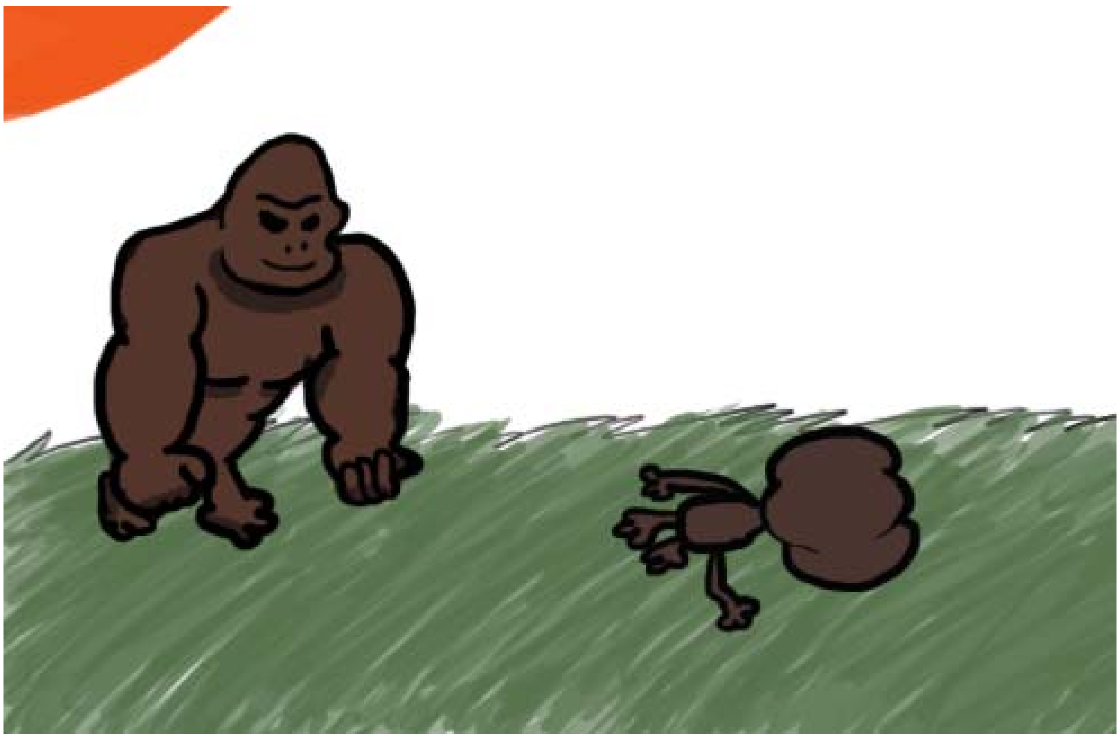


Figure 6-2 'Incorrect Screenshot'

Figure 6-3 'Correct' Screenshot

Visuals, such as the monkey tripping when the answer is incorrect and the monkey kicking dust back at their opponent when the player is correct, were also added in Design 2. These were added for visual cues when the character advances or loses ground, instead of just the player getting further away or closer as they answer questions. These visuals also replace the feedback screens from design 0, allowing us to display right or wrong in a fun way instead of an overly critical one.

6.3 Feedback

As previously stated, Design 2 was field-tested on a group of middle school students.

6.3.1 Setup for Testing

Design 2 was our only design given to a test audience. The audience in question was a classroom of 7th and 8th grade students at Sullivan Middle School in Worcester, MA. Partway through the second term of the project, we were informed of an opportunity to show our work to date to these students, so we began preparing a demo of our design for them. At the end of the term, two representatives from our team, Hao Zhu and Ethan White, presented our progress to the class.

Our demo took the form of a PowerPoint presentation simulating the game we had designed thus far. We created 10 question slides, ‘correct’ and ‘incorrect’ slides for each of these questions, and connected the slide transitions based on which answer the students selected. All of the questions were based on content from Monkey’s Revenge[6].

To approximate the AI aspect of our game, we included a 45-second timer in each question slide. When the timer expired it would be assumed the AI got the question correct before the student could, and the student would be advanced to a ‘incorrect’ slide. Also, our group’s representatives each brought a laptop with an algorithm used to determine how far ahead the player’s monkey should be from the hostile gorilla. At the conclusion of the presentation, the students were shown images of the victory, loss, and map screen slides, and informed of their role in the hypothetical game.

Unfortunately, there were several limiting factors on this experiment which kept us from getting as much out of it as we might have otherwise hoped. When we arrived, after introducing ourselves to the students and moving to the computer lab, we were given about 1 hour to show our demo to about 16 students in groups of 4 or 5. As a

[6] A tutor with game-like elements developed by Dovan Rai of Worcester Polytechnic Institute

result, we were only allotted 15 minutes with each group. This was not a sufficient enough time for them to test our design and give thorough feedback on the game. In the end, we only had time to test our game on two of the four groups, since we spent a little more than 15 minutes with each of them, and also had a larger feedback session with the entire class to finish out the hour.

There were also all the limitations of our demo itself. Though we made the best use we could of PowerPoint's capabilities, it simply wasn't made to be as flexible as games generally are. Some of our design's aesthetics and structure were left out of the demo, such as moving pictures and start menus. Our AI simulation certainly suffered, since it was just a static time limit for each problem. After the demonstration, we determined that the 45-second time limit we used to approximate the AI was much too long for the given problems. This was largely due to the fact that we did not know how well-suited the students would be for the problems we presented them. We later discovered that these students were all in an advanced class for their grade level, so the problems we gave the students were too easy for them to get a proper feel for the pressure of an AI competitor. For the most part, the students solved every problem in a quarter of the allotted time, or less.

6.3.2 Feedback Received

During the testing, we asked the students a predetermined list of questions to encourage more useful feedback. The first thing we asked was whether the students were challenged, and whether they had fun with the game. Unfortunately, few of the students were challenged, since we had underestimated our test group when making the questions. As a result, we got a similar answer to two of our other questions: "What did you think of the AI's difficulty?" and "Did you feel you had too little or too much time to solve the problems?". However, this would be much less of an issue for a more developed version of our design, which would benefit from much more thorough research of its target audience. On the other hand, the students did react positively to our design's concept; most agreed that it was entertaining.

We also asked the students how they felt after getting a question right or wrong in the demo. This was mostly to gauge the emotional response to the screens we had prepared for when students got a question correct or incorrect; the former displayed the player's monkey leaving the gorilla in a large dust cloud, while the latter showed the monkey falling flat on its face. The question of how harsh the feedback should be when the students got a question wrong had generated some discussion when we were working on the design. The students seemed to enjoy the result screens for each question, whether they had got it correct or incorrect. We also asked the students whether they would use our game as a study aid, and many replied that they would.

Our last two questions resulted in the most interesting answers, as they led different students to give conflicting opinions. One question was "What kind of character or story would you like to see in the tutor?" When answering this question, students tended to focus on the nature of the competition. Some liked the scenario in the demo, in which the student helps a monkey escape a gorilla. But others said they'd prefer to play the role of the gorilla chasing the monkey. The main difference between these ideas, in terms of the source of entertainment, is that the first would generate more of a feeling of desperation in the player, and increase the urgency of the gameplay; in other words, it would provoke a prey-like mentality. The second, on the other hand, puts the player in the role of the predator. It gives them the upper hand, and the competition becomes a matter of running down a weaker opponent. Since some students expressed a preference for each, either could be said to be a valid source of entertainment.

Our last question was “Are there any ways for us to make this more fun and helpful to you?” One point that arose from this was that of the AI’s timer’s visibility. Some students enjoyed the extra pressure that arose from not knowing when they would run out of time to answer the question. It seems leaving the timer ambiguous augments the motivation based on competition that was our primary purpose in focusing our design on an AI opponent. However, one student was concerned that not knowing the timer might put too much pressure on the player. If our design were carried through to completion, figuring out how much stress resulted in the maximum amount of motivation would be important, so this type of feedback would require a lot of scrutiny.

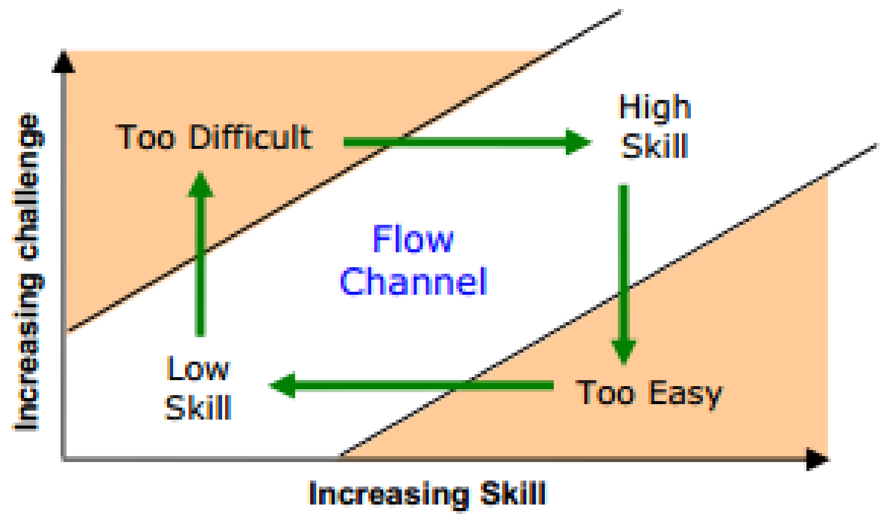
There were also a lot of suggestions we received in response to our last question that could increase the appeal of our design. Multiple students mentioned that they’d like to see bonus levels, with more difficult questions and multiple foes chasing the monkey. Such an idea might be useful to keep the interest of students who feel that the regular levels are too easy; it would be low priority, but it would have a good chance of finding its way into the hypothetical finished product. Some students also mentioned that they would feel more engaged if the game’s characters reacted more dramatically whenever the player answered a question. In the demo, getting a question correct or incorrect would simply result in the player’s monkey going faster or slower, respectively. But one student suggested that perhaps the player’s gain in advantage could be represented in other ways, such as by having the monkey throw things at the gorilla. A finalized version of our design would need to employ many such concepts to maximize its aesthetic appeal.

Though our setup was flawed, and some of our questions allowed for simple ‘yes’ or ‘no’ answers, we were able to glean some useful ideas from our test audience. The most useful pieces of feedback were the ones related to the nature of the competition (whether the player controlled the monkey or the gorilla) and whether the timer should be visible, since these are both important parts of our design’s core goal of engaging students in educational software. It would take a great deal more testing to refine our project to the point where it would be ready for the public.

7 Design 3

Along with all of the feedback and ideas we received from working with the students, we would still have quite a bit to add and refine based on Design 2. Our biggest challenge with Design 3 would be trying to adjust our systems that we already had in place to better accommodate our target audience. From our experience with the test audience, we understand that our current system has a flaw, the inability to predict how much of a head start the player needs and how much leeway the AI must provide so that the player does not lose instantly. These flaws would draw us towards revamping our system of dynamic difficulty adjustment.

The main goal with a dynamic difficulty adjustment system was to give the player a challenge, and to make it a balanced experience. The Psychologist Mihaly Csikszentmihalyi created a chart of the proper flow that makes things enjoyable. So to put it into the context of games, the player needs to feel challenged but still focus on what the game is about and not just what is challenging them. To do this we want the player to stay within the "flow channel" as displayed below. There is a balance that needs to be found in order to create a flowing experience.



Flow state as it transitions over the course of a dynamic experience. Challenge and pacing must ramp to match skill, in order to support continued engagement.

Figure 7-1 Flow Channel

http://cs.northwestern.edu/~hunicke/pubs/Hamlet.pdf

We needed to find a level of challenge since our previous system either ended with the player winning or losing too easily. To find the proper flow we would need to run simulations using Microsoft Excel, or something similar, tweaking the values for the AI, so that their dice rolls can only go so high or so low depending on their distance from the player. For example, say the computer is 5 units away from the player; we wouldn't want it to roll a 5 if it’s the third roll of the game. Instead, we can scale and adjust the values to give the player a fighting chance. Adjusting like this can drastically improve the experience of the game; as it allows us to scale the player’s rolls without their knowledge, so they don't get too far from the computer. If the player is 20 units ahead of the AI, we adjust their rolls to allow tension between the player and the AI opponent to come back. The goal then becomes to find the values that give us a nice 70%-75% win ratio in favor of the player. The big problem we see is if, at the start of the game, players can't get ahead of the AI fast enough, then they will lose almost instantly, so we want to see if they can win in 5 rolls. We can also use this to adjust the starting distance between the player and the AI opponent, which can directly influence how fast the player can lose or how easy it will be if they have a large head start.

To add additional motivating factors for students with different preferences, we would like to start working with the other groups and implementing their ideas. Using our combined knowledge of our game-like elements, we could expand each other's concepts and create two systems that complement each other. For example, one group handled the idea of a reward system that covered customization items. If we were to implement a similar system on top of our current AI system to allow customization of the player’s monkey character, it could add an additional motivator to encourage the player to continue playing after mastering the subject matter. This continued play would allow users to further develop their speed and understanding of the subject matter after mastering the basics. Further implementation of other elements, like hints, could also help students that struggle with the material, and possibly allow for a crutch that they can turn on and off as they see fit. These are all possibilities that could help shape our system to assist different types of students.

There are also smaller systems we would need to refine or fully implement into our design. By completely implementing the map system, we would be able to divide up the different math based subjects, so that each level could be a focus. Doing this would keep the problems from being cluttered and allow students to go to different levels to refine their skills in the different subjects, instead of having to cover a broader focus. We would also like to add other predators that the player would be pursued by based on the different areas on the map; this would keep interest as the player progresses further through the game by adding a different feel to each area. Along with adding the ideas from the students stated earlier, we could truly gear our next design to appeal to our target audience.

7.1 Addressing Design 2 Feedback

In the hypothetical next version of our project's design, we would, for the first time, have feedback from a test group which we could and would incorporate. There were a lot of suggestions that would likely be added to our future plans for the design. One was the idea of allowing the player to play as the gorilla instead of the monkey. This is somewhat similar to our original idea of having a player avatar chase the monkey, but that was less adaptable to multiple scenarios. Now we couple make multiple contexts with similar gameplay more believable by changing the predator that chases the monkey every level. This idea would need more work in more developed versions of our design, but it would be workable, and as the students in our feedback group demonstrated, giving the player the appearance of having an advantage over their opponent is an attractive way of portraying the competition. Since other students seemed to like helping the monkey escape a larger animal, we would probably leave in an option to play the game that way as well, to appeal to as many players as possible.

Another suggestion we received was to allow the monkey to throw things at the AI opponent. This was suggested as a more interesting way to represent the player getting a question right, but we might also have implemented it as an item system, either for students who did well or those who needed extra help. The former might involve adding an item slot, which players could fill by answering a certain number of questions in a row, or answering a question very quickly. They could then use the item to gain an additional advantage over their opponent. Making various items with interesting effects would be a good way to keep players invested in the game. Another way we could use the item system, which would favor struggling students without making things duller for the others, would be to give the player an item periodically, regardless of how well they perform. With some refinement, this kind of item mechanic would make our game much more engaging.

The students also expressed an interest in our game's story. Given more time to work on the design, we would have fleshed out the plot of our game beyond simply "a monkey trying to escape a gorilla." We would add an explanation for why the monkey travels through a series of islands, and what it does to provoke a larger animal on each one. We wouldn't want to expand the story too much, since that would risk upstaging the game's educational purpose. However, the students gave us the impression that they would enjoy the game more if the narrative was a little richer, so we would comply if we had the chance.

Our first run of tests came up with a majority of the players believing that the game was too easy. The problem stemmed from the questions covering material which the students had already mastered. This mismatch between game difficulty and player ability shows that our Dynamic Difficulty Adjustment system demo would need to be changed to keep the issue from occurring. Further balances and tests during the creation of Design 3 would allow us to tweak this system to provide an optimal win/loss ratio.

Another suggestion given by the testers was the inclusion of a hint system. We removed this during an earlier design; the reason for this was to focus on the AI portion of our game. Now that our group has built the base system, we could start expanding it without diluting our main idea. With Design 3 we would begin to work with the other groups to further improve and widen the appeal and depth of our tutor. Working together with the group that created a hint system, we could use their research and guidance to add an effective and unobtrusive hint system to our game.

One of the ideas we were given to add was a system that would allow the player to change the grade level and thus change the questions they were given. Developing this idea alongside the rest of our changes would be a large undertaking. Though it might be a good change, it would deter us from balancing the current system. Adding more questions would create an imbalance and would force us to further adjust the map screen that divides everything up into different math subjects. This could help expand the system for more content.

The students also suggested a bonus stage at the end of each of the levels, much like the old "Sonic the Hedgehog" and "Mario" games. The students provided quite a few interesting ideas for this system. After the monkey escapes the opponent, it would be chased by all of the predators in the game and given rapid fire questions that were more challenging, but were of the same subject of the level they just completed. This idea would make the game more engaging; adding a lightning round would allow for use of more advanced material, and a bonus stage would keep students from being punished for it. Developing and balancing a rapid fire challenge round would take more changes to the Dynamic Difficulty Adjustment system.

8 Future Work

Although we wanted to fine-tune our designs as much as possible, there were just some big ideas that we were unsure of how to approach. These ideas are where future groups could take our designs if they were so inclined.

One of the ideas we would have liked to have implemented were bonus stages. These bonus stages would be mini games that the player would compete against the AI in after they had completed a stage. The big issue was, without a reward system or a system of distributing points in some way, what would the prize be for completing these stages? What would the player get out of it? It could be an additional power up of some kind, something that allowed them to put more space between the opponent and the player, or some sort of boost that doubled their rolls after answering a question correctly. The addition of these power ups would allow for further depth in the game play, but would require more tweaks to the Dynamic Difficulty Adjustments so the player wouldn't completely disable the AI by collecting too many of these power ups in early stages.

The bonus stages would also need games. What direction should these games be taken? Should the player be solving math problems from the subject of the area they just completed, or possibly the next stage so they are rewarded for broader knowledge of the subjects? This could present more options with how to teach the students these subjects.

The other option would be to make the bonus stages fun little mini games that don't necessarily teach the players anything, but are rewards for completing the level. Possibly a single player game that the monkey plays during his travel between each of the different areas. All of these are different ways to approach the bonus stage idea, though we just didn't know which way to approach it or how we could implement it.

Another thought for the future may be to consider where this game would be utilized. Would it be an electronic tutor purchased in a store? Or would it be sold to schools to implement directly with their lessons? Ideally, we would like to determine a means of connecting this tutoring system with schools directly. A teacher could use the tutor to see how well his or her students understand the current material. The teacher could possibly assign it was homework. However, How it would be assigned would be hard for us to understand at this point.

We would like to say we have a good understanding of how much time should be allotted for each question, but we simply do not have enough information on that at this point. A wide range of field tests still need to be conducted with this system to get a grasp on the timing aspect. Hopefully, these tests would lead us to recognize what a good base time would be.

We would also like to make the tutor usable for subjects outside of just math. Would it be feasible to use a tutoring system like this for subject such as history or science. At this point, we simply do not know. We suspect that with some development, the tutor could be altered to suit any material a student sees in a classroom. However, we do not currently know exactly how this could be accomplished. It would be a huge step if we could figure out how to make our tutor more flexible and add more topics.

9 Conclusion

Given more time to work on this project, we would likely have applied our AI to math topics other than line equations; perhaps we could have covered other subjects entirely. Covering these other subjects would involve two main steps: creating new levels and contexts for the additional content, and creating the content itself. The latter would require some research into other educational software, and perhaps other school materials, to generate a pool of problems to test students playing our game. The former would be easier, mostly just writing some new scenarios in which the player's monkey is fleeing some larger foe. If we wanted to make it even more engaging, we could even introduce some other, non-chase-scene situations to keep the player's interest, as long as we kept the element of an AI competitor. This would likely lead to further research on which context resulted in the most learning. If others were to continue our work, they could do even more. They could take our bare bones story and expand it into a full game, with a different miniature plot for each level/school topic, and perhaps a proper overarching plotline, to maximize student engagement. Also, they could arrange sets of problems with more thorough topic coverage, and tailor them for specific grades and skill levels.

A fully implemented version of our project would also incorporate a more flexible difficulty system. To make our AI more useful to a wider range of students, we would make it easier to overcome if a student got questions wrong and more difficult whenever they got a question right. This would avoid the problem of students getting stuck with a difficulty either too easy or too hard for them. In the long term, we would fine tune this process based on such variables as how many questions the student got right or wrong in a row and a record of the student's previous attempts. Others could expand upon this by customizing the AI's difficulty according to each student's scores in their classes. That way, students could have the AI difficulty specifically suited to them from the very first problem.

Eventually, we would have added our AI system to the original Monkey's Revenge. That would have been the best way to figure out how much progress we made: by comparing how much students learned from the original Monkey's Revenge with how much they learned from our version. We could have asked the students afterward what they liked, didn't like, and gained the most out of. In this way, we could have gained a better understanding of how to interest students in educational games. Our findings could even be applied to other games, and further tested and polished.

In summary, there's a lot we could have done to get more out of this project, but that's not to undervalue what we did accomplish. In short, we developed a hypothesis of how AI could be used to improve educational games, honed it based on readings, and tested it on a class of volunteers. Our initial outline of the game involved many elements irrelevant to our primary focus of an AI opponent; all of these non-AI elements, except the map screen, were shaved off in early iterations, to allow us to concentrate more on the AI itself.

We further honed our hypothesis with various readings, to maximize appeal to the various classroom demographics. We discussed including multiple difficulties, to accommodate students of various abilities. We changed the nature of the competition, in the direction of one in which the player helped the monkey escape a larger animal, to increase tension as well as to make the scenarios easier to write. We developed an algorithm for shifting the AI's difficulty during the game, to increase when the opponent fell behind, and decrease if it got too close. This would further enforce the fierceness of the competition. After making these changes and some others, we brought a mock-up of our game before a sample class and received feedback.

Our experiences and this record of it can serve as a useful resource for others interested in the subject of increasing the appeal and effectiveness of educational software. Anyone who plans on implementing a game at all similar to ours can use the preceding paper to refine his or her own hypothesis, however slightly. By archiving our efforts here, we save other researchers the time it took us to generate this data. We hope this research can be the building blocks that lead to a revolution in the educational community.

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